Occurrence of morphologic variability in tick *Hyalomma anatolicum anatolicum* (Acari: Ixodidae)

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Key words:
Hyalomma anatolicum anatolicum, Iran, morphometric study, quantitative characters, qualitative characters, variation.

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Abstract:

BACKGROUND: Taxonomy and identification of the ticks in the genus *Hyalomma*, the most significant vectors of animal and human pathogen agents, have always been debatable. Scientists believe that variation within the taxa of the genus *Hyalomma* is the most important factor which causes misidentification. **OBJECTIVES:** The purpose of this study is to identify valuable characters for male *H. anatolicum anatolicum* by statistical methods. **METHODS:** Tick specimens from 11 geographical regions in Iran including Khuzestan, Lorestan, Sistan & Baluchistan, Yazd, South and Razavi Khorasan provinces as well as an island in southern Iran were studied. Totally, 3 qualitative and 9 quantitative characters were measured by a stereomicroscope armed with scaled lens and the data were analyzed by SPSS software. Also, coefficient of difference (C.D.) was calculated for some important characters. Then, varied shapes of species were drawn with a drawing tube connected to a light stereomicroscope. **RESULTS:** One way ANOVA test revealed significant differences among the quantitative characters in 11 zones ($p<0.001$), also each zone to another zone by LSD. No significant differences ($p>0.14$) in the lateral grooves length/scutum length ratio character were found. The C.D. value equal to 1.28, is a conventional level of subspecific differences but is lesser in this study than this category. **CONCLUSIONS:** The present study focused on the determination a quantitatively relative stable trait for differentiating *H. a. anatolicum*. Therefore, lateral groove is introduced as a reliable character for interspecific identification of species. Our study supports this matter since the value of this character, relative to scutum length in the under studied regions was not statistically significant. This means that the variation range of the mentioned character in the specimens is much limited.

Introduction

Hard ticks taxa of the genus Hyalomma (Acari: Ixodidae) are the most significant vectors of animal and human pathogen agents (Sonenshine et al., 2002). Species status of hard ticks of the genus Hyalomma has a historic scenario. First, C. L. Koch (1844) erected this genus with 16 species, and Neumann (1911) lumped those to one species, *H. aegyptium*, with 3 subspecies and 3 probable species (Koch, 1844; Neumann, 1911). Schulze with Schlottke (1919, 1930) and his followers, for instance Chodziesner (1924) and Kratz (1940), published many series of papers and increased the number of species up to 80 species, subspecies, forms and races (Schulze, 1919; Schulze, 1930; Schulze and

Schlottke, 1930; Chodziedner, 1924; Kratz, 1940). Taxonomy and identification of *Hyalomma* spp. have always been debatable. The reasons for this claim are the studies conducted by Delpy (1936, 1946 and 1949) in Iran, Adler and Feldman-Muhsam (1948), as well as Feldman-Muhsam (1954, 1962). They improved the chaotic taxonomic position of *Hyalomma* through biological methods in laboratory (Delpy, 1936; Delpy, 1946; Delpy, 1949b; Delpy, 1949a; Feldman-Muhsam, 1954; Feldman-Muhsam, 1962). Moreover, Hoogstraal (1956, 1959) elucidated some taxonomic problems related to this genus and deduced that all these complexities in their nomenclature and taxonomy are due to extreme variability in their relatively few morphologic characters because of genetic instability and environmental geographic exchanges. He states that *Hyalomma* probably originated from Iran or southern Russia since we observed the highest species richness in Iran and adjacent countries (Hoogstraal, 1956; Hoogstraal and Kaiser, 1959; Rahbari et al., 2007). Feldman-Muhsam (1962) stated that great variation within *Hyalomma* taxa created two different taxonomic approaches among acarologists as splitting and lumping of species (Feldman-Muhsam, 1962). The small Anatolian *Hyalomma*, *Hyalomma anatolicum anatolicum* (Koch, 1844) (Sensu Pomerantsev, 1946) (Acari: Ixodidae) parasitizes all domestic animals and is one of the most widely distributed *Hyalomma* species in the old world, inhabiting semidesert, steppe, and savanna biotopes in Bangladesh, India, Nepal, all southern Republics of the ex-Soviet Union, Pakistan and Afghanistan to Arabia, Mediterranean areas of southeastern Europe, and Africa almost to the equator (Hoogstraal et al., 1981; Kaiser and Hoogstraal, 1964). The taxonomy *H. a. anatolicum* is confusing and species or subspecies rank of it was discussed many years ago (Pomerantzev, 1950; Hoogstraal and Kaiser, 1959; Feldman-Muhsam, 1962) and is now roughly confirmed as a distinct species (Apanaskevich and Horak, 2005). The diagnosis of some closely related *Hyalomma* taxa is based on a minority of variable characters, for instance, cervical groove length for segregation of *H. anatolicum* from *H. asiaticum*, lateral groove length, central festoon and punctuation for differentiation of *H. a. anatolicum* from *H. marginatum* (subspecies) and arch character for differentiation of both debatable species *H. a. anatolicum* and *H. a. excavatum*, which may cause misidentification in sympatric populations. Thus, having quantitative value of taxonomic characters may be useful in precise identification of species (Mayr and Ashlock, 1991). Moreover, construction of an identification key based on more quantitative data will be possible in the future. The purpose of the present investigation is to identify valuable discriminating characters for male specimens of *H. a. anatolicum* by statistical methods. Also, we would like to explain morphometric variability degree of some characters previously presented as valuable in the several *Hyalomma* identification keys. Regarding the objects of study, only characters which are useful for differentiation of *H. a. anatolicum* to closely related species were selected. This study was performed on the males of *H. a. anatolicum* since the morphologic characters of the females may be obscure when engorged.

Material and Methods

A total of 453 field-collected tick specimens from 11 geographical regions in Iran including Khuzestan, Lorestan, Sistan & Baluchistan, Yazd, South and Razavi Khorasan provinces as well as an island in southern Iran were studied (Table 1). Ticks were examined for preliminary identification of the *H. a. anatolicum* by several *Hyalomma* identification keys (Hoogstraal, 1956; Kaiser and Hoogstraal, 1963; Pomerantzev, 1950) and other related literature (Apanaskevich and Horak, 2005; Delpy, 1936; Hoogstraal and Kaiser, 1959; Mazlum, 1968). The morphologic characters of the specimens were measured by the calibrated stereomicroscope armed with scaled lens (STEMI SR-ZEISS® Germany). The measurements were analyzed using SPSS for windows (version 16). The significance was calculated at 5% level. Afterwards, varied shapes of species in different geographic regions were drawn with a drawing tube connected to a light stereomicroscope. Finally, a formula after Mayr et al (1953) so-called coefficient of difference (C.D.) (Mayr et al., 1953) for calculating overlap in the character of lateral groove length to scutum length ratio and cervical groove length/scutum length ratio (the most important discriminating characters of *H. a.*

Table 1. Statistic of the Scutum parameters (at millimeter). *Least Significance difference. P value in all parameters is similar (p<0.001).

		Statistic					
Parameter	**Zone**	**No.**	**Min.**	**Max.**	**SD**	**Average**	***LSD**
Scutum length	**I**	**51**	**2.43**	**3.53**	**0.26**	**2.97**	**III,IV,V,IX,X**
	II	**62**	**2.29**	**3.79**	**0.27**	**3.03**	**III,V,IX**
	III	**45**	**2.78**	**4.04**	**0.31**	**3.48**	**all zones**
	IV	**39**	**2.62**	**3.65**	**0.27**	**3.13**	**I,III,VII,XI**
	V	**50**	**2.52**	**3.61**	**0.24**	**3.14**	**I,II,III,VI,VII,XI**
	VI	**57**	**2.39**	**3.88**	**0.29**	**3.03**	**III,V,IX**
	VII	**30**	**2.41**	**3.48**	**0.27**	**2.95**	**III,IV,V,IX,X**
	VIII	**30**	**2.33**	**3.42**	**0.28**	**3.05**	**III,IX**
	IX	**40**	**2.82**	**3.73**	**0.24**	**3.23**	**I,II,III,VI,VII,VIII,XI**
	X	**30**	**2.35**	**4.85**	**0.38**	**3.12**	**I,III,VII,XI**
	XI	**19**	**2.60**	**3.34**	**0.21**	**2.93**	**III,IV,V,IX,X**
Scutum width	**I**	**51**	**1.40**	**2.19**	**0.15**	**1.83**	**III,VI,IX,X**
	II	**62**	**1.46**	**2.29**	**0.18**	**1.87**	**III,IX,X**
	III	**45**	**1.77**	**2.83**	**0.25**	**2.27**	**all zones**
	IV	**39**	**1.44**	**2.21**	**0.15**	**1.88**	**III,IX**
	V	**50**	**1.48**	**2.23**	**0.14**	**1.88**	**III,IX**
	VI	**57**	**1.55**	**2.43**	**0.19**	**1.91**	**I,III**
	VII	**30**	**1.19**	**2.14**	**0.35**	**1.83**	**III,IX,X**
	VIII	**30**	**1.51**	**2.14**	**0.14**	**1.88**	**III,IX**
	IX	**40**	**1.75**	**2.37**	**0.15**	**1.98**	**I,II,III,IV,V,VII,VIII,XI**
	X	**30**	**1.59**	**2.19**	**0.17**	**1.97**	**I,II,III,VII,XI**
	XI	**19**	**1.57**	**2.16**	**0.15**	**1.85**	**III,IX,X**
Scutum length/width ratio	**I**	**51**	**1.42**	**1.82**	**0.08**	**1.63**	**III,VI,VII,IX,X**
	II	**62**	**1.44**	**1.85**	**0.08**	**1.63**	**III,VI,VII,IX,X**
	III	**45**	**1.40**	**1.69**	**0.07**	**1.55**	**I,II,IV,V,VIII**
	IV	**39**	**1.49**	**1.96**	**0.09**	**1.66**	**III,VI,VII,VIII,IX,X,XI**
	V	**50**	**1.39**	**1.82**	**0.07**	**1.67**	**III,VI,VII,VIII,IX,X,XI**
	VI	**57**	**1.44**	**1.76**	**0.06**	**1.59**	**I,II,IV,V**
	VII	**30**	**1.43**	**1.82**	**80.0**	**1.56**	**I,II,IV,V**
	VIII	**30**	**1.50**	**1.79**	**80.0**	**1.61**	**III,IV,V**
	IX	**40**	**1.17**	**1.85**	**0.23**	**1.59**	**I,II,IV,V**
	X	**30**	**1.42**	**1.81**	**0.09**	**1.57**	**I,II,IV,V**
	XI	**19**	**1.47**	**1.75**	**0.07**	**1.58**	**IV,V**

anatolicum) among populations was tested. This equation is expressed as follows:

C.D. = (Mb-Ma) / (SDa+SDb)

where Mb and Ma equal the average of two populations. Also SDa and SDb equal the standard deviation of population A and B which were compared.

Although this study was conducted on quantitative characters, nevertheless some qualitative characters are important in diagnosing *H. a. anatolicum* to closely related species, 3 qualitative characters including arch, pigmentation of parma and caudal depression, plus 9 quantitative characters related to scutum, parma and other parameters were measured.

Results

The results for the quantitative character of *H. a. anatolicum* are summarized in Tables 1 to 3. One way ANOVA test revealed significant differences among the quantitative characters in 11 zones (p<0.001), also each zone to another zone by Post Hoc Tests, e.g., Least Significance Difference (LSD). No significant difference (p>0.14) in the lateral grooves length/ scutum length ratio character was found (Figure 3). Variations in some characters are illustrated in Figures. 1 and 2, parts I to III. Observation of qualitative characters revealed the presence of three qualitative characters in the specimens, which is summarized in Table 4. The pigmentation of parma was a high variable in different populations showing some typical specimens in Figure 4. Some data were missed in many zones, because a small number of specimens were incomplete and crashed. LSD between 11 zones showed considerable differences in scutum characters, for instance zone IX to other zones (Table 1). Variation in the size of parma length in our study is very different unlike parma width, which is roughly stable except in zone I (Table 2). The result related the ratio of cervical groove length to scutum length and basis capitulum depression is much anticipated, especially in II, III (the former character), III and XI (the latter character), which is

Table 2. Statistic of the parma parameters (at millimeter). *Containing missing data in zone III and IX. P value in all parameters is similar ($p<0.001$).

		Statistic					
Parameter	**Zone**	**No.**	**Min.**	**Max.**	**SD**	**Average**	***LSD**
***Parma length**	**I**	**51**	**0.10**	**0.21**	**0.03**	**0.15**	**III,VI,IX,X**
	II	**62**	**0.06**	**0.27**	**0.03**	**0.14**	**III,IV,VI,VII,VIII,IX,X**
	III	**44**	**0.10**	**0.31**	**0.05**	**0.19**	
	IV	**39**	**0.12**	**0.21**	**0.02**	**0.16**	**II,III,VI**
	V	**50**	**0.10**	**0.19**	**0.02**	**0.15**	**III,VI,IX,X**
	VI	**57**	**0.12**	**0.19**	**0.03**	**0.18**	**I,II,IV,V,VII,VIII,XI**
	VII	**30**	**0.08**	**0.17**	**0.03**	**0.16**	**II,III,VI**
	VIII	**80**	**0.08**	**0.17**	**0.03**	**0.16**	**II,III,VI**
	IX	**39**	**0.12**	**0.18**	**0.02**	**0.17**	**I,II,III,V**
	X	**30**	**0.12**	**0.18**	**0.03**	**0.17**	**I,II,III,V**
	XI	**19**	**0.10**	**0.17**	**0.03**	**0.16**	**III,VI**
***Parma width**	**I**	**51**	**0.10**	**0.17**	**0.84**	**0.14**	**all zones**
	II	**62**	**0.10**	**0.27**	**0.04**	**0.19**	**I**
	III	**44**	**0.12**	**0.39**	**0.05**	**0.19**	**I**
	IV	**39**	**0.16**	**0.29**	**0.03**	**0.15**	**I**
	V	**50**	**0.12**	**0.29**	**0.03**	**0.19**	**I**
	VI	**57**	**0.10**	**0.27**	**0.03**	**0.19**	**I**
	VII	**30**	**0.10**	**0.23**	**0.02**	**0.18**	**I**
	VIII	**30**	**0.12**	**0.23**	**0.02**	**0.18**	**I**
	IX	**39**	**0.16**	**0.27**	**0.02**	**0.20**	**I**
	X	**30**	**0.16**	**0.29**	**0.03**	**0.21**	**I**
	XI	**19**	**0.14**	**0.27**	**0.03**	**0.19**	**I**
***Parma length/width ratio**	**I**	**51**	**0.06**	**1.60**	**0.40**	**0.50**	**all zones**
	II	**62**	**0.55**	**1.29**	**0.02**	**0.83**	**I,III,VI**
	III	**44**	**0.50**	**1.67**	**0.28**	**0.95**	**I,II,IV,V**
	IV	**39**	**0.46**	**1.25**	**0.17**	**0.18**	**I,III,VI**
	V	**50**	**0.46**	**1.33**	**0.20**	**0.78**	**I,III,VI**
	VI	**57**	**0.64**	**1.80**	**0.20**	**0.96**	**I,II,IV,V,X**
	VII	**30**	**0.36**	**1.29**	**0.20**	**0.88**	**I**
	VIII	**30**	**0.36**	**1.13**	**0.15**	**0.88**	**I**
	IX	**39**	**0.55**	**1.22**	**0.14**	**0.87**	**I**
	X	**30**	**0.54**	**1.22**	**0.16**	**0.84**	**I,VI**
	XI	**19**	**0.43**	**1.14**	**0.19**	**0.86**	**I**

quite significant (Table 3). The coefficient of difference was calculated for some characters. For instance, C.D. between two populations III and VIII for cervical grooves length/scutum length ratio and C.D. between two populations I and VIII for lateral grooves length/scutum length ratio was respectively 1.07 and 0.80, which is in the category joint non-overlap percent (Mayr et al., 1953; p 146). This means that the value is below the level of conventional subspecific distinctness. The results for other zones and characters were also calculated, but not shown.

Discussion

The coefficient of difference was calculated to evaluate the variability of different characteristics, which was also an indicator of the homogeneity of samples. The calculation of C.D. is particularly useful when comparable samples of the same species collected from different localities are investigated (Mayr et al., 1953). The value of C.D. equal to 1.28 is a conventional level of subspecific differences. However in this study, it is less than this category. The present study emphasized the determination of a quantitatively relative stable trait (taxonomic character) to differentiate *H. a. anatolicum* from closely related taxa such as *H. asiaticum asiaticum*, *H. marginatum* (subspecies) and *H. a. excavatum*. Another goal was to confirm some qualitative characters performed in the previous studies about *H. a. anatolicum*. There are few studies based on the methods that involve the comparison and measurement of morphologic characters in the genus *Hyalomma* (Delpy, 1936; Delpy, 1937b; Delpy, 1937a; Mazlum, 1968; Chaudhuri, 1970) as the measurement of those characters is difficult and time consuming. Besides, these characters are few, asymmetric and obscure. For instance, in the present study, determination of the numerical value of a pair of cervical grooves (due to their asymmetry or presence of short lateral furrows and additional depressions) and lateral grooves (that may sometimes be seen to form a line of punctuations) was very difficult. Delpy (1936, 1937a) described all the

Table 3. Statistic of the other quantitative parameters (at millimeter). *containing missing data in zone IV, VI, VII and IX. **containing missing data in zone I. P value in all parameters is similar (p<0.001).

		Statistic					
Parameter	**Zone**	**No.**	**Min.**	**Max.**	**SD**	**Average**	***LSD**
***Basis capituli depression**	I	51	0.00	0.06	0.01	0.02	II,III,VII,VIII
	II	62	0.00	0.08	0.01	0.03	all zones except III
	III	45	0.02	0.06	0.01	0.03	all zones exept II
	IV	38	0.00	0.04	0.00	0.02	II,III
	V	50	0.00	0.06	0.00	0.02	II,III
	VI	56	0.02	0.06	0.00	0.02	II,III
	VII	29	0.02	0.04	0.00	0.02	I,II,III
	VIII	30	0.01	0.04	0.00	0.02	I,II,III
	IX	39	0.02	0.04	0.00	0.02	II,III
	X	30	0.00	0.04	0.00	0.02	II,III
	XI	19	0.02	0.04	0.00	0.02	II,III
***cervical grooves length/scutum length ratio**	I	49	0.25	0.51	0.06	0.33	III,VIII,XI
	II	62	0.21	0.45	0.05	0.32	III,V,VI,VIII,XI
	III	45	0.26	0.80	0.10	0.42	all zones
	IV	39	0.23	0.45	0.04	0.31	III,V,VI,XI
	V	50	0.23	0.57	0.07	0.34	II,III,IV,VIII,IX,X,XI
	VI	57	0.25	0.51	0.05	0.35	II,III,IV,VIII,IX,X,XI
	VII	30	0.20	0.46	0.06	0.32	III,VIII,XI
	VIII	30	0.19	0.39	0.03	0.28	I,II,III,V,VI,VII,IX,XI
	IX	40	0.26	0.45	0.04	0.31	III,V,VI,VIII,XI
	X	30	0.24	0.43	0.05	0.31	III,V,VI,XI
	XI	19	0.30	0.83	0.13	0.56	all zones

Table 4. The presence of qualitative parameters in the studied specimens. I: specimens with qualitative parameter. II: specimens without qualitative parameter. *containing missing data in all qualitative parameters except arch.

	Qualitative parameters		
***Group**	**Arch (No.)**	**Pigmented parma (No.)**	**Caudal depression (No.)**
I	61	318	90
II	392	134	361

parasitic stages of *H. dromedarii* by measuring the length and width of scutum, basis capitulum, palpi II and III, and spiracular plate in addition to some comparative characters (Delpy, 1936; Delpy, 1937a). He also reported the range of variation in the morphologic characters of *H. schulzei*, e.g., length and width of corpse, corpse length to capitulum length ratio and IV genua length ratio and the other characters (Delpy, 1937b). Hoogstraal (1956) reported the range of variation in subanal shields of the reared *H. a. anatolicum* (Hoogstraal and Kaiser, 1959). Mazlum (1978), after studying many *Hyalomma* specimens, came to the conclusion that *H. asiaticum asiaticum* may occur in Iran and focused on some quantitative characters (especially scutum length) that are valuable for the differentiation of this species with three other closely related taxa including *H. a. anatolicum*, *H. a. excavatum* and *H. dromedarii* (Mazlum, 1968). Scutum size (body length in literature) in the genus *Hyalomma* is variable and could not be considered as a valuable character as shown in the present study. This issue was confirmed in many *Hyalomma* identification keys (Apanaskevich and Horak, 2005; Hoogstraal, 1956; Hoogstraal and Kaiser, 1959; Hoogstraal et al., 1981). Our observations show that some populations of *H. a. anatolicum* were smaller, frailer or more robust than the other populations. This phenomenon is discovered in Kaiser-Hoogstraal's study. They stated that populations of *H. a. anatolicum* in Afghanistan and eastward, eastern Turkey and Iran, are smaller and frailer than the other parts of Turkey and areas to the west. Also, a certain proportion of individuals in many samples is exceptionally long and narrow (Kaiser and Hoogstraal, 1963). Kaiser and Hoogstraal (1964) express that this is especially true for *H. a. anatolicum*, *H. dromedarii* and *H. aegyptium* which are non-endemic species introduc-

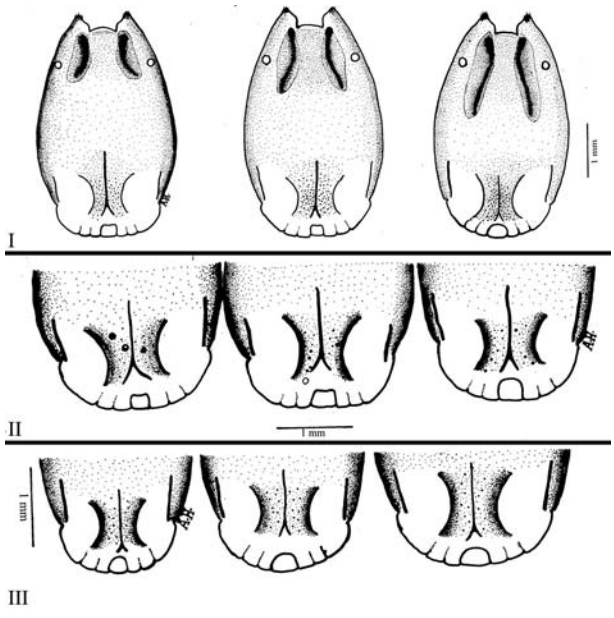

Figure 1. *Hyalomma anatolicum anatolicum*, dorsal view; variation in morphologic characters: part I: variation in cervical groove/scutum length ratio, from left to right short, intermediate and tall representative specimens. part II: variation in parma length, from left to right short, intermediate and tall representative specimens. part III: variation in parma width, from left to right narrow, intermediate and wide representative specimens. original.

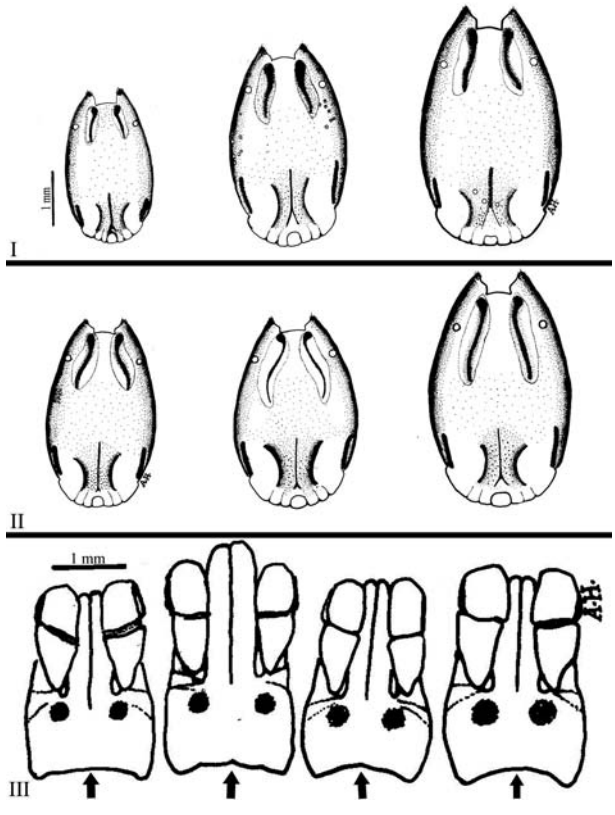

Figure 2. *Hyalomma anatolicum anatolicum*, dorsal view; variation in morphologic characters: part I: variation in scutum length, from left to right short, intermediate and tall representative specimens. part II: variation in scutum width, from left to right narrow, intermediate and wide representative specimens. part III: variation in basis capituli dorsoposterior depression, from left to right smooth, semi smooth and ridged, semi deep and deep representative specimens. original.

ed to Indian subregion (Kaiser and Hoogstraal, 1964). The median festoon (parma) is a suitable segregating character for interspecific discrimination of *Hyalomma* taxa. However, variation in its size, shape, and color was considerable (Hoogstraal, 1956; Adler and Feldman-Muhsam, 1948). For example, parma is not seen in the representative specimens of *H. marginatum* (subspecies) unlike *H. a. anatolicum*. The size of parma is remarkably large and subrectangular in *H. schulzei* and may be triangular in its closely related taxa, e.g., *H. dromedarii* (Hoogstraal, 1956) and is very small in other taxa (Hoogstraal et al., 1981). Mazlum (1978) considered that parma is a multishaped character that may be suitable for the distinction of three *Hyalomma* species. He observed oval, oval, subtriangular and subrectangular shapes in *H. a. anatolicum*, *H. a. excavatum*, *H. asiaticum asiaticum* and *H. dromedarii*, respectively (Mazlum, 1968). Variation in the size and shape of parma *H. a. anatolicum* is an important factor in its misidentification. Generally, in the previous study, the color of parma in *H. a. anatolicum* was almost invariably pale (Hoogstraal and Kaiser, 1959); however, it is sometimes dark and may cause misi-dentification with *H. marginatum* (subspecies) in which the color of parma is dark. Adler and Feldman-Muhsam (1948) used pigmented and unpigmented parma character in the Palestinian *Hyalomma* identification key. They believed that this character could separate *H. marginatum* from the

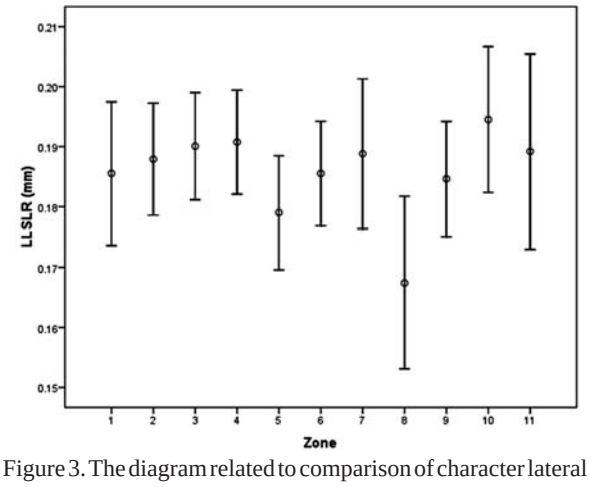

Figure 3. The diagram related to comparison of character lateral grooves length/scutum length ratio (LLSLR) in 11 zones, upper and lower level of bars show standard deviation range.

other species, e.g., *H. savignyi* (now *H. a. anatolicum*) (Adler and Feldman-Muhsam, 1948).

The basis capitulum depression (depth between cornua) is a specific character for *H. asiaticum*. Pomerantzev (1950) considered this character for discriminating *H. asiaticum* from *H. anatolicum*, but stated more concave and slightly concave ambiguous phrases for the two species, respectively, which is obscure therefore identification may be subjective (Pomerantzev, 1950). Kaiser and Hoogstraal (1964) used the depth of this character plus its angularity or smoothness for the diagnosis of *H. asiaticum asiaticum* from *H. a. anatolicum*, respectively (Kaiser and Hoogstraal, 1964). In the present study, we measured this character quantitatively and obtained the range of numerical variations. The arch (bridge-like extension, pons or fusion of paraparmal festoons) is a qualitative character which is debatable for the identification of two closely related species *H. a. anatolicum* and *H. a. excavatum* (Apanaskevich and Horak, 2005; Hoogstraal and Kaiser, 1959). In the former species, this character is not seen as a connection of pair festoons II anteriorly and is usually seen as a narrow smooth or warty area in position of posteromedian groove to parma connection. But, in the latter species, the semicircle bridge-like extension or usually the fusion of paraparmal festoons may be obviously seen (Hoogstraal and Kaiser, 1959). Adler and Feldman-Muhsam (1948) studied the arch character in tick *H. savignyi* (now=*H. a. anatolicum*). They believed that arch is a very important trait that causes the misidentification of the closely related *Hyalomma* species (Adler and Feldman-Muhsam, 1948). Hoogstraal (1956) reported a reared Egyptian *Hyalomma* species similar to *H. excavatum* whose caudal area may be concave. He stated that the depression of the posterior part of the scutum between two smooth lateral ridges in typical specimens of *H. a. anatolicum* may be strong (Hoogstraal, 1956). It is well known that caudal depression is typically characteristic to some closely related *Hyalomma*, e.g., *H. asiaticum asiaticum* and *H. dromedarii*. Interestingly, this character may also be seen in some populations of *H. a. anatolicum*. The lateral groove is a reliable character for interspecific segregating of some *Hyalomma* taxa, especially *H. a. anatolicum* (Delpy, 1936; Hoogstraal, 1956; Kaiser and Hoogstraal, 1964; Serdyukova, 1956). The present investigation supports the results of these studies since the value of this character relative to scutum length in all study regions was not statistically significant. This means that the range of variation of this character in the understudied specimens is quite limited. Our goal from studying this important character was to obtain a numerical value for it that is qualitatively described in many *Hyalomma* identification keys through expressions, e.g., "lateral grooves not extending beyond the posterior third of the scutum" or "lateral grooves short, not reaching central third of the scutum", which are ambiguous explanations (Apanaskevich and Horak, 2005; Delpy, 1936; Hoogstraal, 1956; Kaiser and Hoogstraal, 1964; Serdyukova, 1956). Hoogstraal (1956) believed that lateral groove length is an important character for discriminating the genus *Hyalomma* (Hoogstraal, 1956). However, Pomerantzev (1950) as well as Adler and Feldman-Muhsam (1948) never mentioned this character in their *Hyalomma* identification keys (Adler and Feldman-Muhsam, 1948; Pomerantzev, 1950).

The cervical grooves like the lateral grooves described through expressions, e.g., "cervical grooves short, not reaching mid-scutum" or "cervical grooves are seen as slight depression" that are vague descriptive statements. This study considers the length of the cervical grooves quantitatively as the length of this character in the specimens was statistically significant, and this character is variable in different populations of *H. a. anatolicum*. Kaiser and Hoogstraal (1964) emphasized the elongation

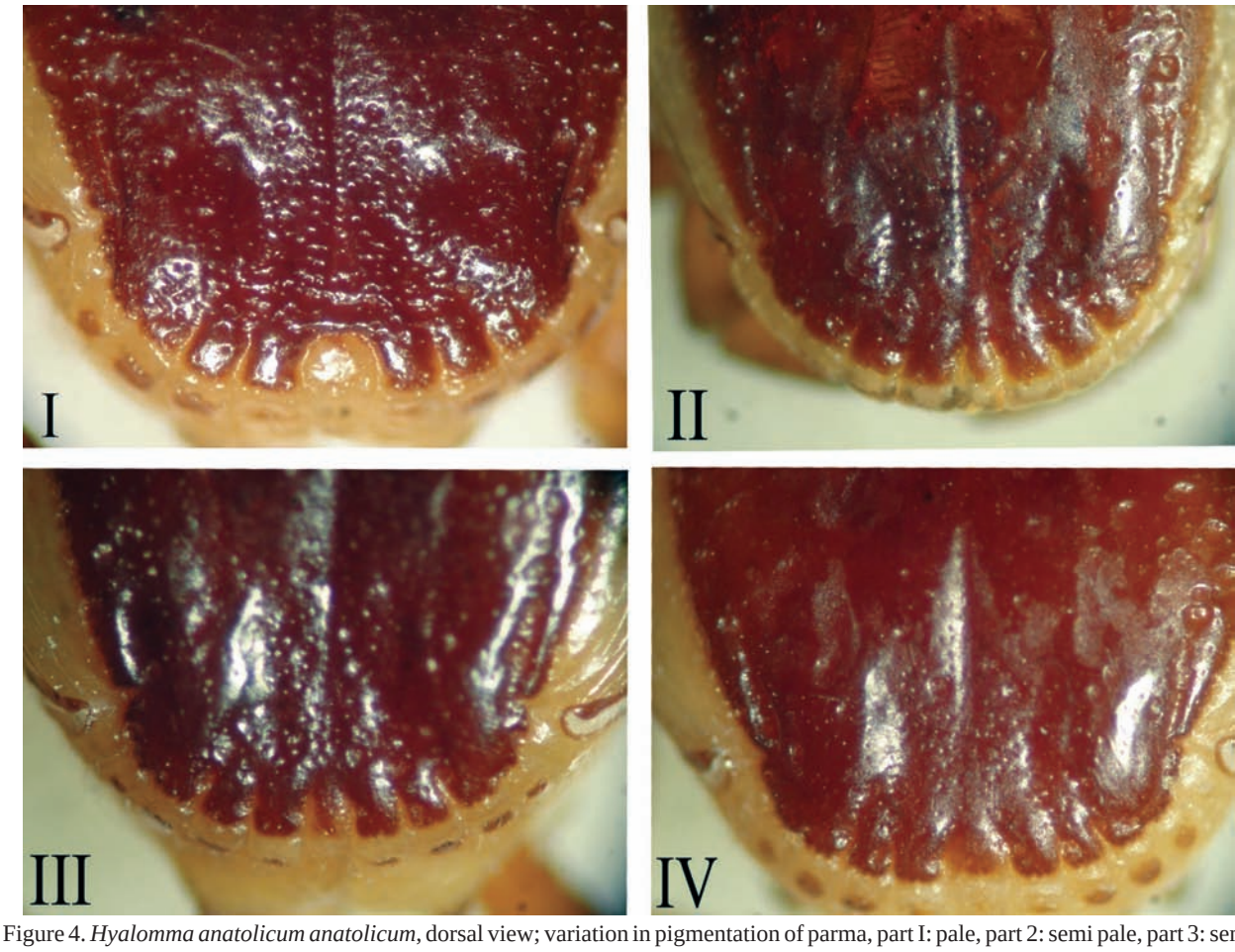

Figure 4. *Hyalomma anatolicum anatolicum*, dorsal view; variation in pigmentation of parma, part I: pale, part 2: semi pale, part 3: semi dark, part 4: dark (may be misidentified to *H. marginatum* group). original.

and depth of cervical grooves for *H. asiaticum asiaticum* in comparison with *H. a. anatolicum* (Kaiser and Hoogstraal, 1964), while Pomerantzev (1950) did not state it for length of cervical grooves, but considered the depth of this character as a valuable taxonomic feature (Pomerantzev, 1950). In the present study, we observed a number of specimens of *H. a. anatolicum* with longer cervical grooves. It seems that the length of this character may not be a reliable taxonomic character unlike its depth which may be useful.

Conclusion

As a result, diagnosis of *Hyalomma* spp may not be completely correct unless the taxonomist observes many specimens from species and is familiar with taxonomic traits, features or characters and their variation in the geographical distribution area. The range of variation in the quantity of the characters in *H. a. anatolicum* suggests that key construction for *Hyalomma* species must be dependent on a comprehensive morphometric study conducted on the *Hyalomma* taxa, at least, all over Iran. Moreover, recently Haller's organ that is situated on tarsus legs I of all ticks was studied on three closely related *Hyalomma* including *H. a. anatolicum*, *H. a. excavatum* and *H. asiaticum asiaticum* (unpublished data), and good results were obtained. Thus, we recommended this character be studied in other *Hyalomma* spp.

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References

1. Adler, S., Feldman-Muhsam, B. (1948) A note on the genus *Hyalomma* Koch in Palestine. Parasitology. 39: 95-101.
2. Apanaskevich, D.A., Horak, I.G. (2005) The genus *Hyalomma* Koch, 1844. II. Taxonomic status of *H. (Euhyalomma) anatolicum* Koch, 1844 and *H. (E.) excavatum* Koch, 1844 (Acari: Ixodidae) with redescriptions of all stages. Acarina. 13: 181-197.
3. Chaudhuri, R.P. (1970) Description of the immature stages of *Hyalomma (Hyalommina) kumari* Sharif, 1928 (Acarina: Ixodidae) and redescription of the adults, with notes on its hosts and distribution. Parasitology. 61: 43-53.
4. Chodziedner, M. (1924) Beiträge zur Kenntnis der Zecken mit besonderer Berücksichtigung der Gattung *Hyalomma* Koch. Zool Jahrb. p. 47.
5. Delpy, L.P. (1936) Notes sur les Ixodidés du genre *Hyalomma* (Koch). Ann Parasitol Hum Comp. 14: 206-245.
6. Delpy, L.P. (1937a) Description de *Hyalomma dromedarii* (Koch 1884) morphologie de la larve et de la nymphe. Ann Parasitol Hum Comp. 14: 481-486.
7. Delpy, L.P. (1937b) Notes sur les Ixodidae du genre *Hyalomma* Koch II. *Hyalomma schulzei* Olenev 1931. Ann Parasitol Hum Comp. 14: 419-430.
8. Delpy, L.P. (1946) Révision par les voies expérimentales du genre *Hyalomma* C. L. Koch, 1884 (Acarina. Ixodoidea. Ixodidae). Note préliminaire. Arch l'Inst d'Hess. 2: 61-93.
9. Delpy, L.P. (1949a) Essai critique de synonymie du genre *Hyalomma* C. L. Koch 1844 depuis Linné, 1758. Ann Parasitol Hum Comp. 24: 464-494.
10. Delpy, L.P. (1949b) Révision par les voies expérimentales du genre *Hyalomma* C. L. Koch, 1884. 2e partie. Ann Parasitol Hum Comp. 24: 97-109.
11. Feldman-Muhsam, B. (1954) Revision of the genus *Hyalomma* I. Description of Koch's types. Bull Res Counc Isr. 4: 150-170.
12. Feldman-Muhsam, B. (1962) Revision of the genus *Hyalomma* III. *H. lusitanicum* Koch and *H. anatolicum* K. Parasitology. 52: 211-219.
13. Hoogstraal, H. (1956) African Ixodoidea. I. Ticks of the Sudan (with special reference to Equatoria Province and with preliminary reviews of the genera *Boophilus,Margaropus* and *Hyalomma*). Washington DC, USA.
14. Hoogstraal, H., Kaiser, M.N. (1959) Observation on Egyptian *Hyalomma* ticks (Ixodoidea, Ixodidae).5. Biological notes and differences in identity of *H. anatolicum* and its subspecies *anatolicum* Koch and *excavatum* Koch, among Russian and other workers. Identity of *H. lusitanicum* Koch. Ann Entomol Soc Am. 52: 243-261.
15. Hoogstraal, H., Wassef, H.Y., Büttiker, W. (1981) Ticks (Acarina) of Saudi Arabia. Fam. Argasidae, Ixodidae. Fauna Saud Arab. 3: 25-110.
16. Kaiser, M.N., Hoogstraal, H. (1964) The *Hyalomma* ticks (Ixodoidea: Ixodidae) of Pakistan, India and Ceylon, with keys to subgenera and species Acarologia. 6: 257-286.
17. Kaiser, M.N., Hoogstraal, H. (1963) The *Hyalomma* Ticks (Ixodoidea, Ixodidae) of Afghanistan. J Parasitol. 49: 130-139.
18. Koch, C.L. (1844) Systematische Übersicht über die Ordnung der Zecken. Archiv für Naturgeschichte 10: 217-239.
19. Kratz, W. (1940) Die Zeckengattung *Hyalomma* Koch. Parasitol Res. 11: 510-562.
20. Mayr, E., Ashlock, P.D. (1991) Principle of Systematic Zoology. McGraw-Hill, New York,USA.
21. Mayr, E., Linsley, G., Usinger, R.L. (1953) Methods and Principles of Systematic Zoology. McGraw-Hill, New York, USA.
22. Mazlum, Z. (1968) *Hyalomma asiaticum asiaticum* Schulze and Schlottke, 1929. Its distribution, hosts, seasonal activity, life cycle, and role in transmission of bovine theileriosis in Iran. Acarologia. 10: 437-442.
23. Neumann, L.G. (1911) Ixodidae. Berlin: Verlag von R. Friedländer und Sohn.
24. Pomerantzev, B.I. (1950) Fauna of USSR arachnida: Ixodid ticks (Ixodidae). Moscow: Zoological Institute Akademii Nauk USSR.
25. Rahbari, S., Nabian, S., Shayan, P. (2007) Primary

report on distribution of tick fauna in Iran. Parasitol Res 101 Suppl. 2: S175-177.
26. Schulze, P. (1919) Bestimmungstabelle für das Zeckengenus *Hyalomma* Koch. Sitzungsber Gesellschaft Naturforsch Freunde Berlin. 5: 189-196.
27. Schulze, P. (1930) Die Zeckengattung *Hyalomma* I. (*H. aegyptium* L., *Detritum* P. Sch., *Volgense* P. Sch. U. Schlottke, *H. scupense* P. Sch. und *H. uralense* P. Sch. U. Schlottke). Parasitol Res. 3: 22-48.
28. Schulze, P., Schlottke, E. (1930) Bestimmungstabellen für das Zeckengenus *Hyalomma* Koch s. str. Sitzungsber Abhandlungen Naturforsch Gesellschaft Rostock. 2: 32-46.
29. Serdyukova, G.V. (1956) Ixodid ticks of USSR fauna. Zool Inst Akad Nauk SSSR. [Translation from Russian]. 64: 79-84.
30. Sonenshine, D.E., Lane, R.S., Nicholson, W.L. (2002) Ticks (Ixodida). In: Medical And Veterinary Entomology. Mullen, G.R., Durden, L.A. (eds.). Academic Press. USA.

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بروز تنوع مورفولوژیک در کنه *Hyalomma anatolicum anatolicum* (Acari: IxodidaeRhipicephalinae)

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چکیده

زمینه مطالعه: تاکسونومی و شناسایی کنه‌های جنس *Hyalomma* که معروفترین ناقل‌های عوامل بیماریزای انسان و حیوان هستند همواره بحث برانگیز بوده است. محققان معتقدند که تنوع در یک گونه از این کنه مهمترین عامل در این زمینه است. **هدف:** هدف از این مطالعه شناسایی صفات با ارزش برای نرهای *H. anatolicum anatolicum* با استفاده از روش‌های آماری است. **روش کار:** در مجموع نمونه‌ها از ۱۱ منطقه جغرافیایی در ایران شامل خوزستان، لرستان، سیستان و بلوچستان، یزد، خراسان جنوبی و رضوی، همچنین یک جزیره در جنوب ایران مطالعه شد. به طور کلی ۳ صفت کیفی به همراه ۹ صفت کمی توسط استریومیکروسکوپ مجهز به لنز مدرج اندازه گیری و داده‌ها توسط نرم افزار SPSS مورد تحلیل قرار داده شدند. همچنین ضریب تغییرات برای برخی از صفات مهم محاسبه گردید. سپس اشکال متنوع از نمونه‌ها به وسیله لوله ترسیم متصل به استریومیکروسکوپ نقاشی شد. **نتایج:** تست آنووای یک طرفه اختلافات معنی‌داری در بین صفات کمی در ۱۱ ناحیه ($p<۰/۰۰۱$) و نیز هر ناحیه با ناحیه دیگر توسط تست LSD نشان داد. اختلاف معنی‌داری در صفت نسبت شیار جانبی به طول اسکوتوم دیده نشد ($p<۰/۱۴$). ضریب تغییرات برابر با ۱/۲۸ سطح مبنا برای اختلافات زیر گونه‌ای است اما در این مطالعه کمتر از این مقدار به دست آمد. **نتیجه گیری نهایی:** مطالعه حاضر که برای تعیین یک صفت ثابت از نظر کمی برای افتراق *H. a. anatolicum* تاکید داشت بنابراین شیار جانبی را به عنوان یک صفت قابل اعتماد برای جداسازی بین گونه‌ای برخی گونه‌های *Hyalomma* معرفی می‌کند زیرا مقدار این صفت در مقایسه با طول اسکوتوم از لحاظ آماری معنی‌ار نشده است. این بدین معناست که تنوع در صفت فوق الذکر در نمونه‌های مورد مطالعه ما خیلی کم بوده است.

واژه‌های کلیدی: *Hyalomma anatolicum anatolicum*، ایران، مطالعه مورفومتریک، صفات کمی، صفات کیفی، تنوع.

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